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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton-CN (Auden)**

Certificate No: **CD1880V3-1155\_Jan13**

## CALIBRATION CERTIFICATE

Object **CD1880V3 - SN: 1155**

Calibration procedure(s) **QA CAL-20.v6  
Calibration procedure for dipoles in air**

Calibration date: **January 22, 2013**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 10 dB Attenuator	SN: 5047.2 (10q)	27-Mar-12 (No. 217-01527)	Apr-13
Probe ER3DV6	SN: 2336	28-Dec-12 (No. ER3-2336_Dec12)	Dec-13
Probe H3DV6	SN: 6065	28-Dec-12 (No. H3-6065_Dec12)	Dec-13
DAE4	SN: 781	29-May-12 (No. DAE4-781_May12)	May-13

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-12)	In house check: Oct-13
Power sensor HP E4412A	SN: MY41495277	01-Apr-08 (in house check Oct-12)	In house check: Oct-13
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-12)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13
RF generator R&S SMT-06	SN: 832283/011	27-Aug-12 (in house check Oct-12)	In house check: Oct-14

Calibrated by:	Name <b>Claudio Leubler</b>	Function Laboratory Technician	Signature 
Approved by:	Name <b>Fin Bomholt</b>	Deputy Technical Manager	

Issued: January 24, 2013

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#### References

- [1] ANSI-C63.19-2007  
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
- [2] ANSI-C63.19-2011  
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

#### Methods Applied and Interpretation of Parameters:

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with the standards [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm (15 mm for [2]) above the top metal edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections. It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY5 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminated by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E-field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1] and [2], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 10 mm (15 mm for [2]) (in z) above the metal top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, in the plane above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

<b>DASY Version</b>	DASY5	V52.8.5
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	HAC Test Arch	
<b>Distance Dipole Top - Probe Center</b>	10mm 15mm	
<b>Scan resolution</b>	dx, dy = 5 mm	
<b>Frequency</b>	1730 MHz $\pm$ 1 MHz 1880 MHz $\pm$ 1 MHz	
<b>Input power drift</b>	< 0.05 dB	

### Maximum Field values at 1730 MHz

<b>H-field 10 mm above dipole surface</b>	condition	<b>interpolated maximum</b>
Maximum measured	100 mW input power	<b>0.502 A / m <math>\pm</math> 8.2 % (k=2)</b>

<b>E-field 10 mm above dipole surface</b>	condition	<b>Interpolated maximum</b>
Maximum measured above high end	100 mW input power	158.9 V / m
Maximum measured above low end	100 mW input power	149.8 V / m
Averaged maximum above arm	100 mW input power	<b>154.4 V / m <math>\pm</math> 12.8 % (k=2)</b>

<b>E-field 15 mm above dipole surface</b>	condition	<b>Interpolated maximum</b>
Maximum measured above high end	100 mW input power	99.8 V / m
Maximum measured above low end	100 mW input power	98.1 V / m
Averaged maximum above arm	100 mW input power	<b>99.0 V / m <math>\pm</math> 12.8 % (k=2)</b>

### Maximum Field values at 1880 MHz

<b>H-field 10 mm above dipole surface</b>	condition	<b>interpolated maximum</b>
Maximum measured	100 mW input power	<b>0.471 A / m <math>\pm</math> 8.2 % (k=2)</b>

<b>E-field 10 mm above dipole surface</b>	condition	<b>Interpolated maximum</b>
Maximum measured above high end	100 mW input power	144.1 V / m
Maximum measured above low end	100 mW input power	138.3 V / m
Averaged maximum above arm	100 mW input power	<b>141.2 V / m <math>\pm</math> 12.8 % (k=2)</b>

<b>E-field 15 mm above dipole surface</b>	condition	<b>Interpolated maximum</b>
Maximum measured above high end	100 mW input power	90.8 V / m
Maximum measured above low end	100 mW input power	90.2 V / m
Averaged maximum above arm	100 mW input power	<b>90.5 V / m <math>\pm</math> 12.8 % (k=2)</b>

## Appendix

### Antenna Parameters

#### Nominal Frequencies

Frequency	Return Loss	Impedance
1730 MHz	33.3 dB	52.0 $\Omega$ - 1.0 j $\Omega$
1880 MHz	18.3 dB	43.4 $\Omega$ + 9.2 j $\Omega$
1900 MHz	19.0 dB	46.2 $\Omega$ + 10.1 j $\Omega$
1950 MHz	23.5 dB	50.4 $\Omega$ + 6.7 j $\Omega$
2000 MHz	19.4 dB	42.7 $\Omega$ + 6.8 j $\Omega$

#### 3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

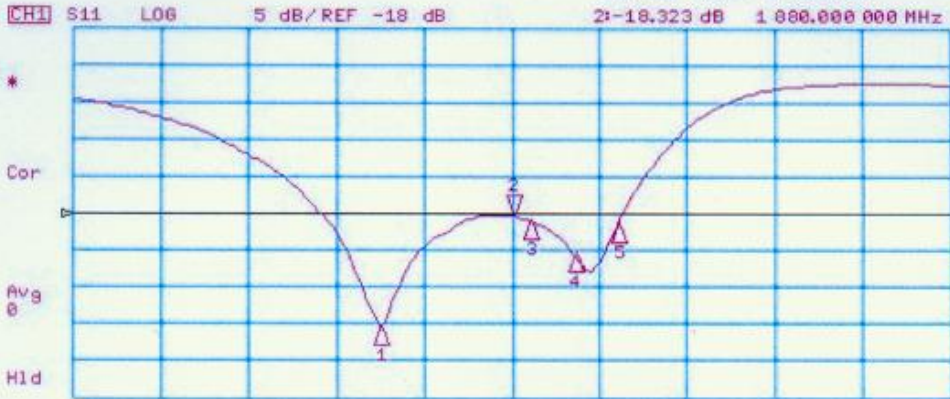
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.

Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

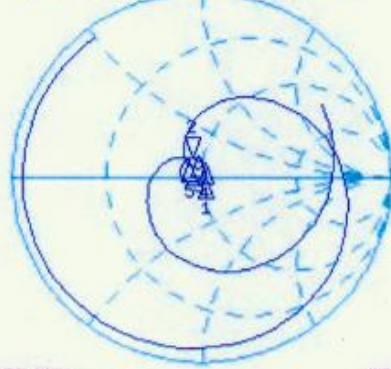
# Impedance Measurement Plot

22 Jan 2013 17:18:23



CH2 S11 1 U FS 2: 43.355  $\Omega$  9.2402  $\Omega$  782.25  $\mu\text{H}$  1 880.000 000 MHz

Del  
Cor  
Avg 0  
H1d



CH2 Markers

1:	51.971 $\Omega$	-978.70 $\mu\text{H}$	1.73000 GHz
3:	46.188 $\Omega$	18.146 $\mu\text{H}$	1.90000 GHz
4:	50.416 $\Omega$	6.6953 $\mu\text{H}$	1.95000 GHz
5:	42.688 $\Omega$	6.7969 $\mu\text{H}$	2.00000 GHz

CENTER 1 880.000 000 MHz

SPAN 1 880.000 000 MHz

## DASY5 H-field Result

Date: 22.01.2013

Test Laboratory: SPEAG Lab2

**DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: CD1880V3 - SN: 1155**

Communication System: CW; Frequency: 1880 MHz, Frequency: 1730 MHz

Medium parameters used:  $\sigma = 0$  S/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: H3DV6 - SN6065; ; Calibrated: 28.12.2012
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 29.05.2012
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.8.5(1059); SEMCAD X 14.6.8(7028)

**Dipole H-Field measurement @ 1880MHz/H-Scan - 1880MHz d=10mm/Hearing Aid Compatibility Test (41x181x1):**

Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 0.5000 A/m; Power Drift = 0.00 dB

PMR not calibrated. PMF = 1.000 is applied.

H-field emissions = 0.4711 A/m

**Near-field category: M2 (AWF 0 dB)**

PMF scaled H-field

Grid 1 M2	Grid 2 M2	Grid 3 M2
0.407 A/m	0.431 A/m	0.414 A/m
Grid 4 M2	Grid 5 M2	Grid 6 M2
0.441 A/m	0.471 A/m	0.456 A/m
Grid 7 M2	Grid 8 M2	Grid 9 M2
0.399 A/m	0.435 A/m	0.422 A/m

**Dipole H-Field measurement @ 1880MHz/H-Scan - 1730MHz d=10mm/Hearing Aid Compatibility Test (41x181x1):**

Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 0.5340 A/m; Power Drift = 0.00 dB

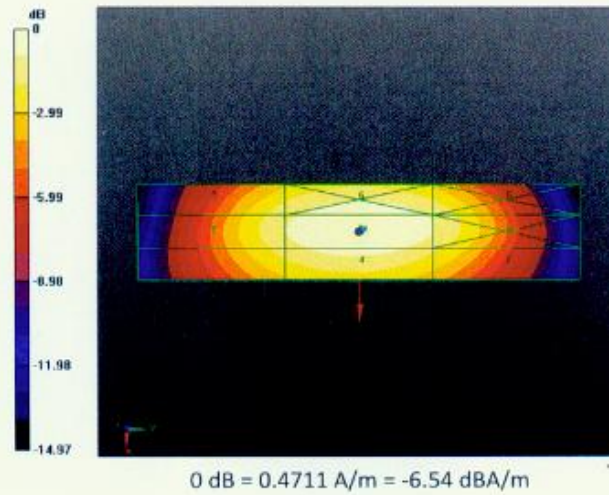
PMR not calibrated. PMF = 1.000 is applied.

H-field emissions = 0.5016 A/m

**Near-field category: M2 (AWF 0 dB)**

PMF scaled H-field

Grid 1 M2 0.417 A/m	Grid 2 M2 0.442 A/m	Grid 3 M2 0.424 A/m
Grid 4 M2 0.466 A/m	Grid 5 M2 0.502 A/m	Grid 6 M2 0.485 A/m
Grid 7 M2 0.407 A/m	Grid 8 M2 0.445 A/m	Grid 9 M2 0.432 A/m



## DASY5 E-field Result

Date: 22.01.2013

Test Laboratory: SPEAG Lab2

**DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: CD1880V3 - SN: 1155**

Communication System: CW; Frequency: 1880 MHz, Frequency: 1730 MHz

Medium parameters used:  $\sigma = 0$  S/m,  $\epsilon_r = 1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 28.12.2012;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 29.05.2012
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.8.5(1059); SEMCAD X 14.6.8(7028)

**Dipole E-Field measurement @ 1880MHz/E-Scan - 1880MHz d=10mm/Hearing Aid Compatibility Test (41x181x1):**

Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 158.6 V/m; Power Drift = 0.02 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 144.1 V/m

**Near-field category: M2 (AWF 0 dB)**

PMF scaled E-field

Grid 1 M2 133.2 V/m	Grid 2 M2 138.3 V/m	Grid 3 M2 135.0 V/m
Grid 4 M3 87.36 V/m	Grid 5 M3 90.00 V/m	Grid 6 M3 86.70 V/m
Grid 7 M2 134.1 V/m	Grid 8 M2 144.1 V/m	Grid 9 M2 141.9 V/m



**Dipole E-Field measurement @ 1880MHz/E-Scan - 1880MHz d=15mm/Hearing Aid Compatibility Test (41x181x1):**

Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 158.4 V/m; Power Drift = 0.03 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 90.17 V/m

**Near-field category: M3 (AWF 0 dB)**

PMF scaled E-field

Grid 1 M3	Grid 2 M3	Grid 3 M3
88.89 V/m	90.79 V/m	89.91 V/m
Grid 4 M3	Grid 5 M3	Grid 6 M3
69.62 V/m	70.44 V/m	69.49 V/m
Grid 7 M3	Grid 8 M3	Grid 9 M3
87.24 V/m	90.17 V/m	89.49 V/m

**Dipole E-Field measurement @ 1880MHz/E-Scan - 1730MHz d=10mm/Hearing Aid Compatibility Test (41x181x1):**

Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 174.7 V/m; Power Drift = 0.01 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 149.8 V/m

**Near-field category: M2 (AWF 0 dB)**

PMF scaled E-field

Grid 1 M2	Grid 2 M2	Grid 3 M2
144.2 V/m	149.8 V/m	146.4 V/m
Grid 4 M3	Grid 5 M3	Grid 6 M3
99.58 V/m	102.9 V/m	99.22 V/m
Grid 7 M2	Grid 8 M2	Grid 9 M2
148.4 V/m	158.9 V/m	156.4 V/m

**Dipole E-Field measurement @ 1880MHz/E-Scan - 1730MHz d=15mm/Hearing Aid Compatibility Test (41x181x1):**

Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 175.3 V/m; Power Drift = -0.01 dB

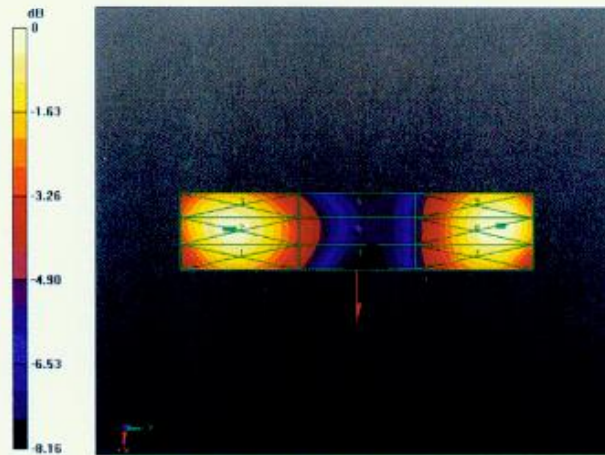
PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 98.12 V/m

**Near-field category: M3 (AWF 0 dB)**

PMF scaled E-field

Grid 1 <b>M3</b> 95.89 V/m	Grid 2 <b>M3</b> 98.12 V/m	Grid 3 <b>M3</b> 97.01 V/m
Grid 4 <b>M3</b> 75.66 V/m	Grid 5 <b>M3</b> 76.83 V/m	Grid 6 <b>M3</b> 75.74 V/m
Grid 7 <b>M3</b> 96.58 V/m	Grid 8 <b>M3</b> 99.78 V/m	Grid 9 <b>M3</b> 98.86 V/m



0 dB = 144.1 V/m = 43.17 dBV/m

## IMPORTANT NOTICE

### USAGE OF THE DAE 4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

**Battery Exchange:** The battery cover of the DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE:** Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

**E-Stop Failures:** Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

**Repair:** Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

**DASY Configuration Files:** Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

**Important Note:**

**Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.**

**Important Note:**

**Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.**

**Important Note:**

**To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.**



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Accreditation No.: **SCS 108**

Client **Sporton-SZ (Auden)**

Certificate No: **DAE4-1303\_Nov12**

**CALIBRATION CERTIFICATE**

Object **DAE4 - SD 000 D04 BJ - SN: 1303**

Calibration procedure(s) **QA CAL-06.v25  
Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **November 22, 2012**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	02-Oct-12 (No:12728)	Oct-13
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V2.1	SE UWS 053 AA 1001	05-Jan-12 (in house check)	In house check: Jan-13

Calibrated by:	Name <b>Dominique Steffen</b>	Function <b>Technician</b>	Signature 
Approved by:	Name <b>Fin Bomholt</b>	Function <b>R&amp;D Director</b>	Signature 

Issued: November 22, 2012

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Accreditation No.: **SCS 108**

## Glossary

DAE data acquisition electronics  
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ V, full range = -100...+300 mV

Low Range: 1LSB = 61nV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	405.550 $\pm$ 0.1% (k=2)	403.442 $\pm$ 0.1% (k=2)	404.889 $\pm$ 0.1% (k=2)
Low Range	3.96640 $\pm$ 0.7% (k=2)	3.99328 $\pm$ 0.7% (k=2)	3.98825 $\pm$ 0.7% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	96 $^{\circ}$ $\pm$ 1 $^{\circ}$
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## Appendix

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	199996.55	0.29	0.00
Channel X + Input	20001.52	0.99	0.00
Channel X - Input	-19998.29	2.33	-0.01
Channel Y + Input	199997.48	1.15	0.00
Channel Y + Input	20000.22	-0.19	-0.00
Channel Y - Input	-19999.56	1.25	-0.01
Channel Z + Input	199998.87	2.09	0.00
Channel Z + Input	19999.15	-1.27	-0.01
Channel Z - Input	-20001.58	-0.84	0.00

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2001.79	0.98	0.05
Channel X + Input	202.24	1.01	0.50
Channel X - Input	-197.13	1.37	-0.69
Channel Y + Input	2001.99	1.39	0.07
Channel Y + Input	201.05	-0.12	-0.06
Channel Y - Input	-198.78	-0.11	0.05
Channel Z + Input	2001.30	0.73	0.04
Channel Z + Input	200.51	-0.69	-0.34
Channel Z - Input	-200.51	-1.87	0.94

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading ( $\mu\text{V}$ )	Low Range Average Reading ( $\mu\text{V}$ )
Channel X	200	8.94	7.27
	-200	-5.42	-7.07
Channel Y	200	5.98	5.59
	-200	-7.30	-6.99
Channel Z	200	-5.29	-4.96
	-200	1.96	2.26

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X ( $\mu\text{V}$ )	Channel Y ( $\mu\text{V}$ )	Channel Z ( $\mu\text{V}$ )
Channel X	200	-	1.26	-4.81
Channel Y	200	7.42	-	2.20
Channel Z	200	10.05	6.11	-

#### 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	15931	17527
Channel Y	15630	16766
Channel Z	16140	14768

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10M $\Omega$

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	1.14	0.03	1.91	0.37
Channel Y	-0.32	-1.56	0.61	0.39
Channel Z	-0.34	-2.00	1.57	0.61

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

#### 7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

#### 8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

#### 9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton-SZ (Auden)**

Certificate No: **ER3-2528\_Mar13**

## CALIBRATION CERTIFICATE

Object **ER3DV6 - SN:2528**

Calibration procedure(s) **QA CAL-02.v6, QA CAL-25.v4  
Calibration procedure for E-field probes optimized for close near field  
evaluations in air**

Calibration date: **March 27, 2013**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	29-Mar-12 (No. 217-01508)	Apr-13
Power sensor E4412A	MY41498087	29-Mar-12 (No. 217-01508)	Apr-13
Reference 3 dB Attenuator	SN: S5054 (3c)	27-Mar-12 (No. 217-01531)	Apr-13
Reference 20 dB Attenuator	SN: S5086 (20b)	27-Mar-12 (No. 217-01529)	Apr-13
Reference 30 dB Attenuator	SN: S5129 (30b)	27-Mar-12 (No. 217-01532)	Apr-13
Reference Probe ER3DV6	SN: 2328	12-Oct-12 (No. ER3-2328_Oct12)	Oct-13
DAE4	SN: 789	18-Sep-12 (No. DAE4-789_Sep12)	Sep-13
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	<b>Dimce Iliev</b>	<b>Laboratory Technician</b>	
Approved by:	<b>Katja Pokovic</b>	<b>Technical Manager</b>	
			Issued: March 27, 2013
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			



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Accreditation No.: **SCS 108**

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Multilateral Agreement for the recognition of calibration certificates

### Glossary:

NORM <sub>x,y,z</sub>	sensitivity in free space
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

### Calibration is Performed According to the Following Standards:

- IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005
- CTIA Test Plan for Hearing Aid Compatibility, April 2010.

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>*: Assessed for E-field polarization  $\vartheta = 0$  for XY sensors and  $\vartheta = 90$  for Z sensor ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide).
- NORM(f)<sub>x,y,z</sub>* = *NORM<sub>x,y,z</sub>* \* *frequency\_response* (see Frequency Response Chart).
- DCP<sub>x,y,z</sub>*: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR*: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A<sub>x,y,z</sub>*; *B<sub>x,y,z</sub>*; *C<sub>x,y,z</sub>*; *D<sub>x,y,z</sub>*; *VR<sub>x,y,z</sub>*: *A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup.
- Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle*: The angle is assessed using the information gained by determining the *NORM<sub>x</sub>* (no uncertainty required).

# Probe ER3DV6

## SN:2528

Manufactured: April 26, 2010  
Calibrated: March 27, 2013

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

## DASY/EASY - Parameters of Probe: ER3DV6 - SN:2528

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu V/(V/m)^2$ )	1.96	1.60	1.87	$\pm 10.1\%$
DCP (mV) <sup>5</sup>	98.3	100.4	99.8	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB/ $\mu V$	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	184.9	$\pm 3.3\%$
		Y	0.0	0.0	1.0		202.3	
		Z	0.0	0.0	1.0		199.4	
10011- CAA	UMTS-FDD (WCDMA)	X	2.95	64.3	17.4	2.91	112.3	$\pm 0.9\%$
		Y	3.37	67.4	19.0		120.2	
		Z	3.27	66.6	18.5		117.9	
10021- CAA	GSM-FDD (TDMA, GMSK)	X	24.91	99.4	29.0	9.39	143.7	$\pm 3.0\%$
		Y	23.10	99.4	29.8		104.4	
		Z	29.49	99.8	29.8		125.7	
10039- CAA	CDMA2000 (1xRTT, RC1)	X	5.03	67.0	19.5	4.57	114.3	$\pm 1.2\%$
		Y	5.04	67.1	19.4		124.7	
		Z	4.90	66.4	18.9		120.5	
10081- CAA	CDMA2000 (1xRTT, RC3)	X	4.07	66.3	18.9	3.97	110.3	$\pm 0.7\%$
		Y	4.07	66.3	18.9		119.8	
		Z	3.95	65.5	18.3		116.1	
10170- CAA	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	6.41	68.6	21.4	6.52	109.2	$\pm 2.5\%$
		Y	6.36	68.3	21.1		120.0	
		Z	6.25	67.4	20.4		117.7	
10172- CAA	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	X	16.29	96.0	36.9	9.21	138.3	$\pm 3.5\%$
		Y	10.50	81.1	29.6		106.5	
		Z	11.80	81.6	29.0		111.2	
10173- CAA	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	16.36	95.1	36.6	9.48	139.5	$\pm 4.1\%$
		Y	10.37	79.7	29.0		105.5	
		Z	12.52	82.6	29.5		112.8	
10176- CAA	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	X	6.36	68.3	21.2	6.52	109.5	$\pm 2.5\%$
		Y	6.34	68.1	21.0		120.1	
		Z	6.28	67.5	20.4		117.8	
10178- CAA	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	X	6.41	68.6	21.3	6.52	109.6	$\pm 2.5\%$
		Y	6.40	68.4	21.2		120.5	
		Z	6.26	67.4	20.3		117.8	
10232- CAA	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	X	16.94	96.5	37.3	9.48	139.4	$\pm 4.1\%$
		Y	10.62	80.5	29.3		106.3	
		Z	12.52	82.6	29.5		112.6	

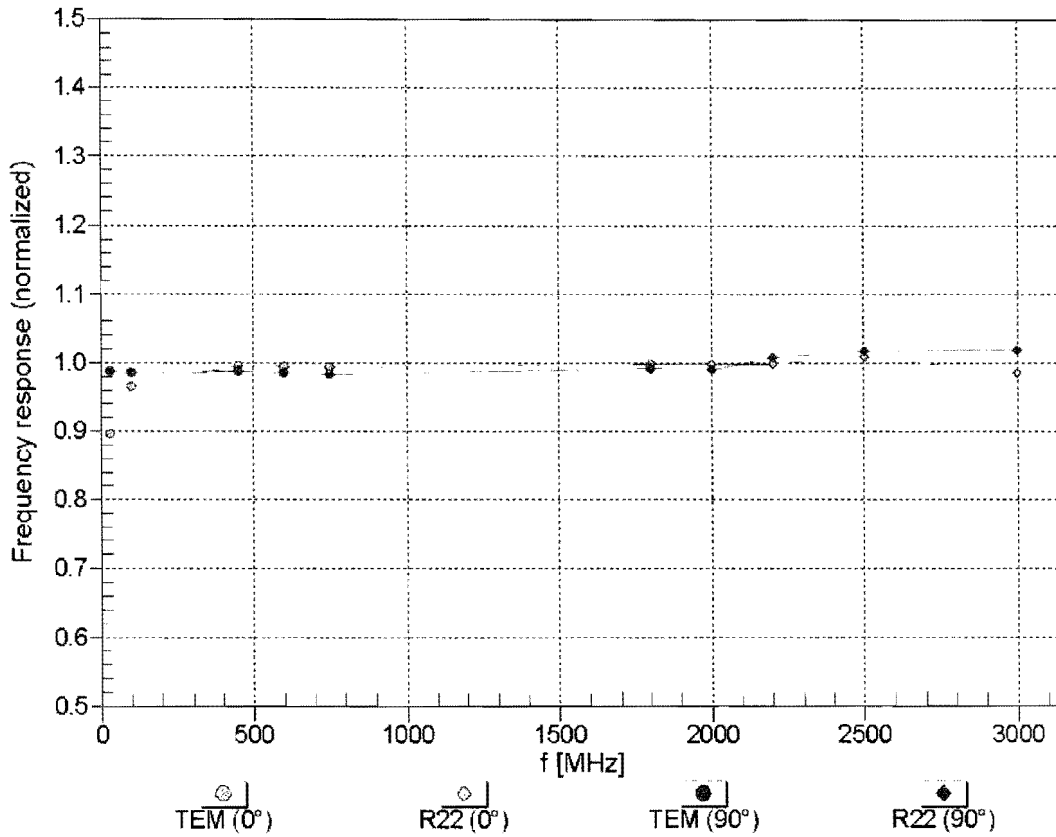
10234-CAA	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, QPSK)	X	16.33	96.0	37.0	9.21	138.9	±4.1 %
		Y	10.37	80.6	29.4		105.7	
		Z	11.94	82.0	29.2		111.0	
10235-CAA	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	X	16.10	94.6	36.4	9.48	140.0	±3.8 %
		Y	10.44	79.9	29.0		105.9	
		Z	12.32	82.1	29.3		111.9	
10237-CAA	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)	X	15.90	95.2	36.6	9.21	138.8	±3.8 %
		Y	10.52	81.1	29.6		106.1	
		Z	11.76	81.5	28.9		111.3	
10276-CAA	CDMA2000 (1xRTT, RC1, 1/8 Rate)	X	16.31	90.8	35.6	12.97	55.7	±1.7 %
		Y	12.87	82.5	31.5		62.8	
		Z	13.01	80.5	29.8		65.3	

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution corresponds to a coverage probability of approximately 95%.

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

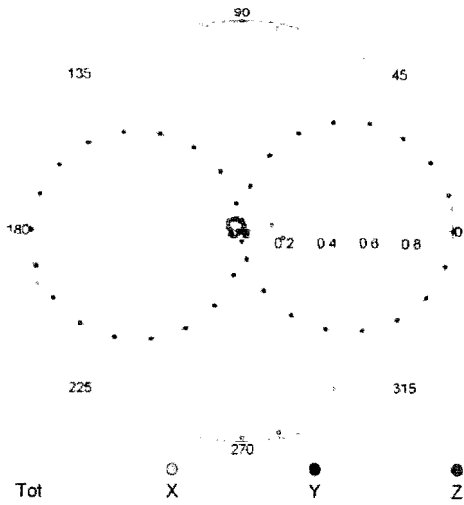
# Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



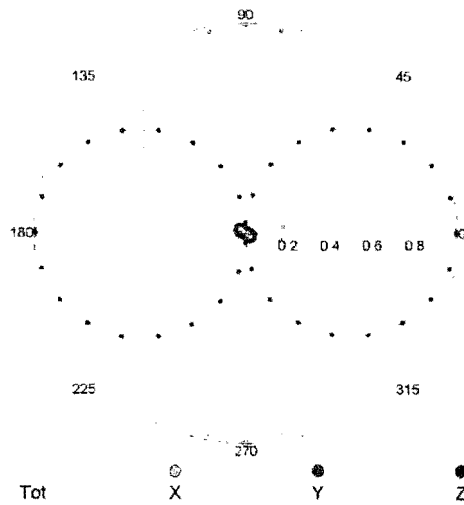
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

### Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$

f=600 MHz, TEM,  $0^\circ$

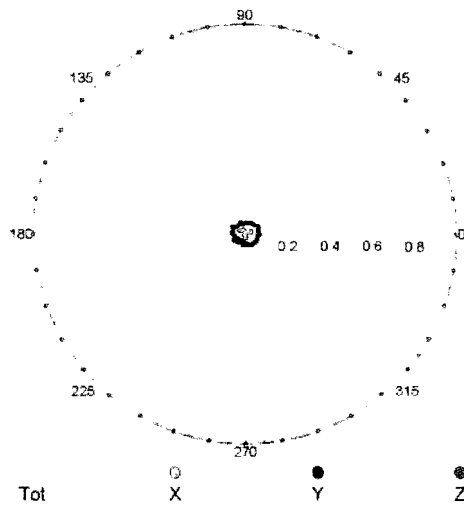


f=2500 MHz, R22,  $0^\circ$

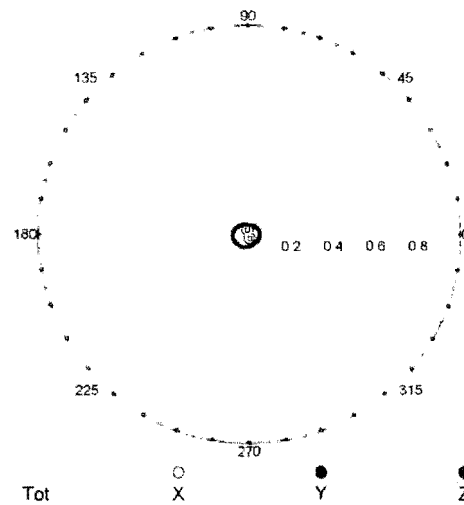


### Receiving Pattern ( $\phi$ ), $\theta = 90^\circ$

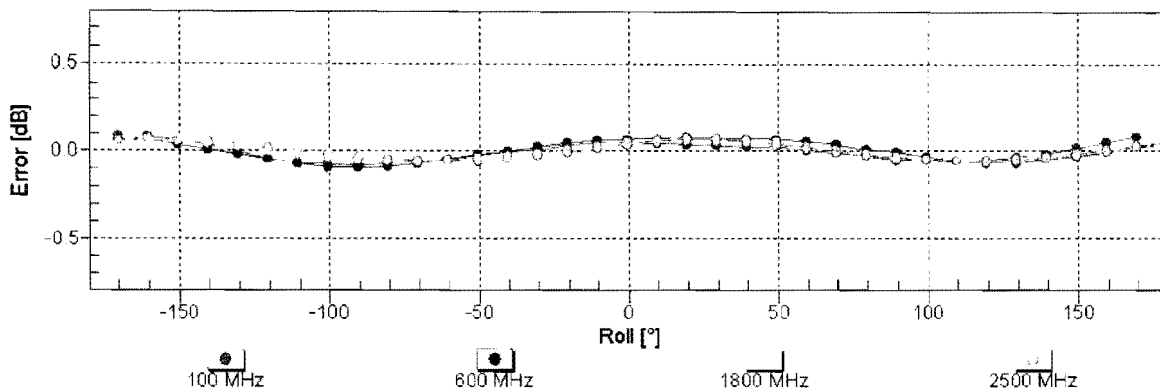
f=600 MHz, TEM,  $90^\circ$



f=2500 MHz, R22,  $90^\circ$

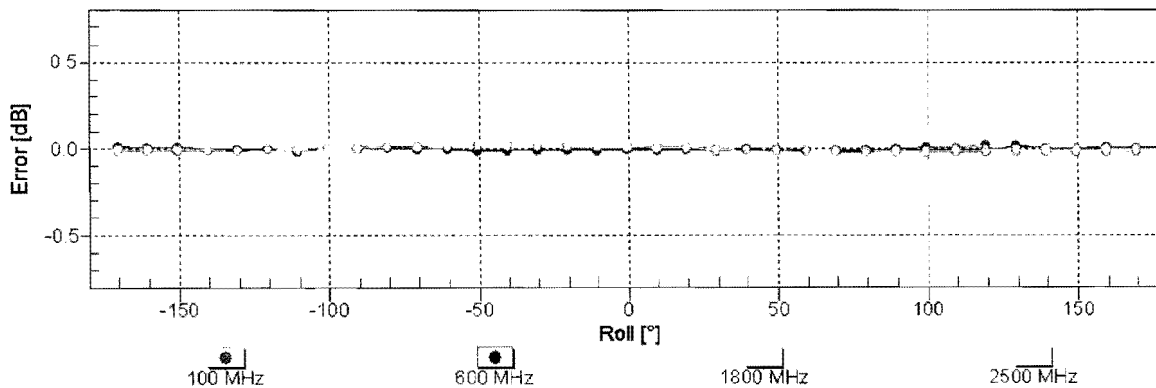


### Receiving Pattern ( $\phi$ ), $\vartheta = 0^\circ$



Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

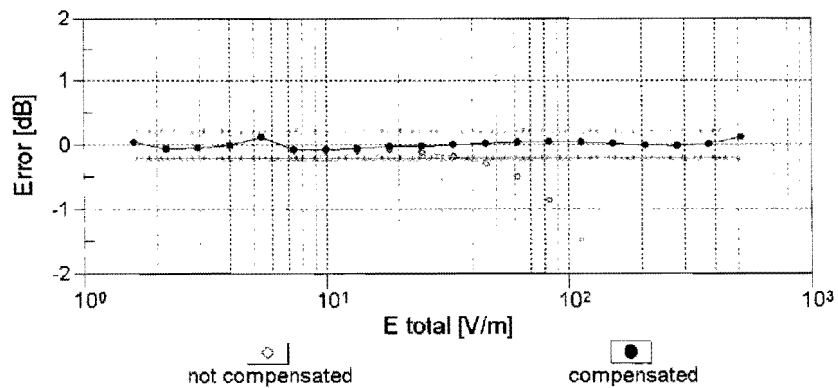
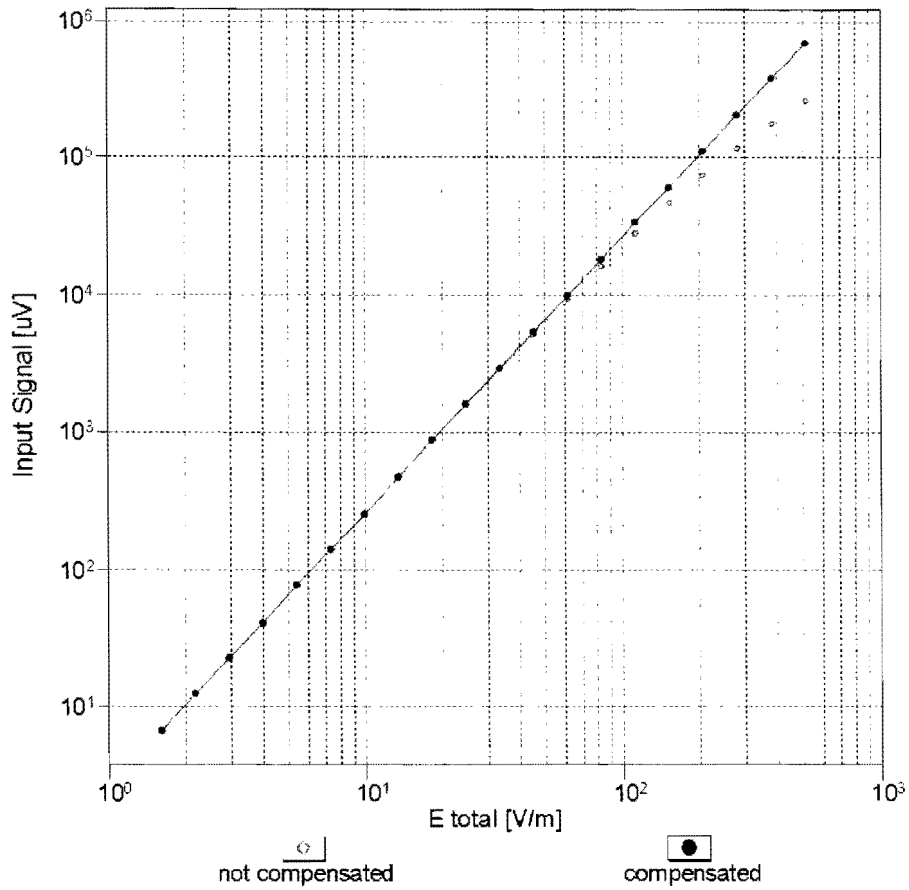
### Receiving Pattern ( $\phi$ ), $\vartheta = 90^\circ$



Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)



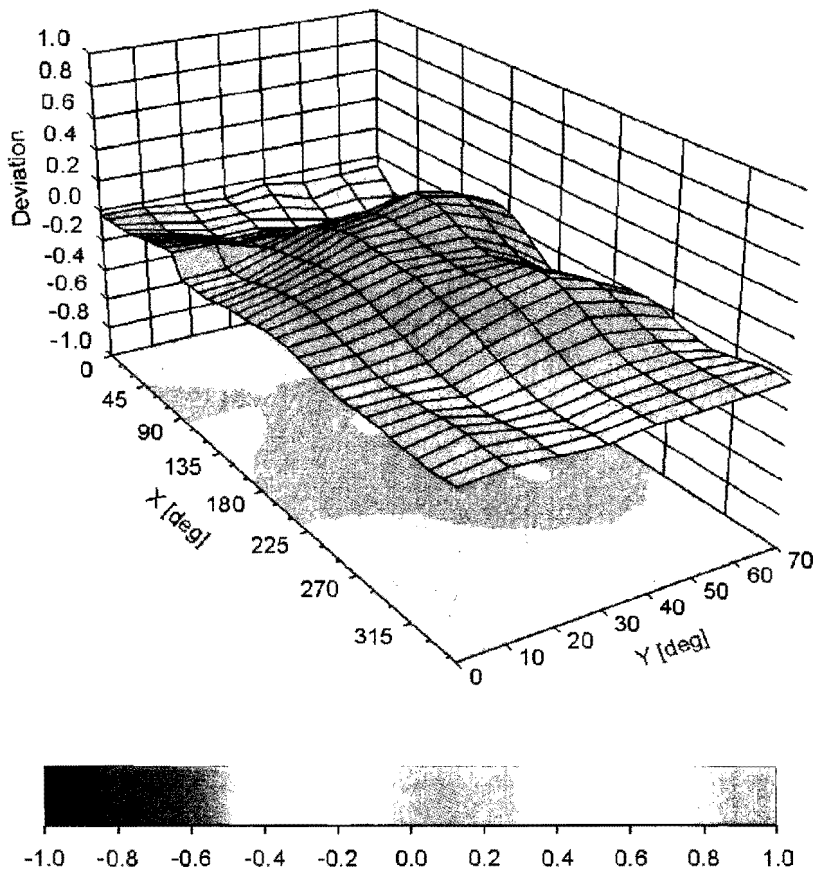
### Dynamic Range f(E-field) (TEM cell , f = 900 MHz)



Uncertainty of Linearity Assessment: ± 0.6% (k=2)

# Deviation from Isotropy in Air

Error ( $\phi, \vartheta$ ),  $f = 900$  MHz



**Uncertainty of Spherical Isotropy Assessment:  $\pm 2.6\%$  ( $k=2$ )**

## DASY/EASY - Parameters of Probe: ER3DV6 - SN:2528

### Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	-20.6
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	8 mm
Probe Tip to Sensor X Calibration Point	2.5 mm
Probe Tip to Sensor Y Calibration Point	2.5 mm
Probe Tip to Sensor Z Calibration Point	2.5 mm



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Accreditation No.: **SCS 108**

Client **Sporton-SZ (Auden)**

Certificate No: **H3-6342\_Mar13**

## CALIBRATION CERTIFICATE

Object **H3DV6 - SN:6342**

Calibration procedure(s) **QA CAL-03.v6, QA CAL-25.v4  
Calibration procedure for H-field probes optimized for close near field  
evaluations in air**

Calibration date: **March 27, 2013**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	29-Mar-12 (No. 217-01508)	Apr-13
Power sensor E4412A	MY41498087	29-Mar-12 (No. 217-01508)	Apr-13
Reference 3 dB Attenuator	SN: S5054 (3c)	27-Mar-12 (No. 217-01531)	Apr-13
Reference 20 dB Attenuator	SN: S5086 (20b)	27-Mar-12 (No. 217-01529)	Apr-13
Reference 30 dB Attenuator	SN: S5129 (30b)	27-Mar-12 (No. 217-01532)	Apr-13
Reference Probe H3DV6	SN: 6182	12-Oct-12 (No. H3-6182_Oct12)	Oct-13
DAE4	SN: 789	18-Sep-12 (No. DAE4-789_Sep12)	Sep-13
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	<b>Dimce Iliev</b>	<b>Laboratory Technician</b>	
Approved by:	<b>Katja Pokovic</b>	<b>Technical Manager</b>	

Issued: March 27, 2013

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Accreditation No.: **SCS 108**

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### Glossary:

NORM <sub>x,y,z</sub>	sensitivity in free space
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

### Calibration is Performed According to the Following Standards:

- IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005.
- CTIA Test Plan for Hearing Aid Compatibility, April 2010.

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>*: Assessed for E-field polarization  $\vartheta = 0$  for XY sensors and  $\vartheta = 90$  for Z sensor ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide).
- X, Y, Z(f)\_a0a1a2* = *X, Y, Z\_a0a1a2* \* *frequency\_response* (see Frequency Response Chart).
- DCP<sub>x,y,z</sub>*: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR*: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>*: *A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup.
- Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle*: The angle is assessed using the information gained by determining the *X\_a0a1a2* (no uncertainty required).

# Probe H3DV6

## SN:6342

Manufactured: August 3, 2010  
Calibrated: March 27, 2013

Calibrated for DASYS/EASY Systems  
(Note: non-compatible with DASYS2 system!)

## DASY/EASY - Parameters of Probe: H3DV6 - SN:6342

### Basic Calibration Parameters

		Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (A/m / $\sqrt{\text{mV}}$ )	a0	2.61E-003	2.66E-003	2.86E-003	$\pm 5.1 \%$
Norm (A/m / $\sqrt{\text{mV}}$ )	a1	-4.97E-006	-2.28E-005	9.28E-005	$\pm 5.1 \%$
Norm (A/m / $\sqrt{\text{mV}}$ )	a2	-2.95E-005	-3.50E-005	-4.48E-005	$\pm 5.1 \%$
DCP (mV) <sup>B</sup>		94.1	91.4	93.3	

### Modulation Calibration Parameters

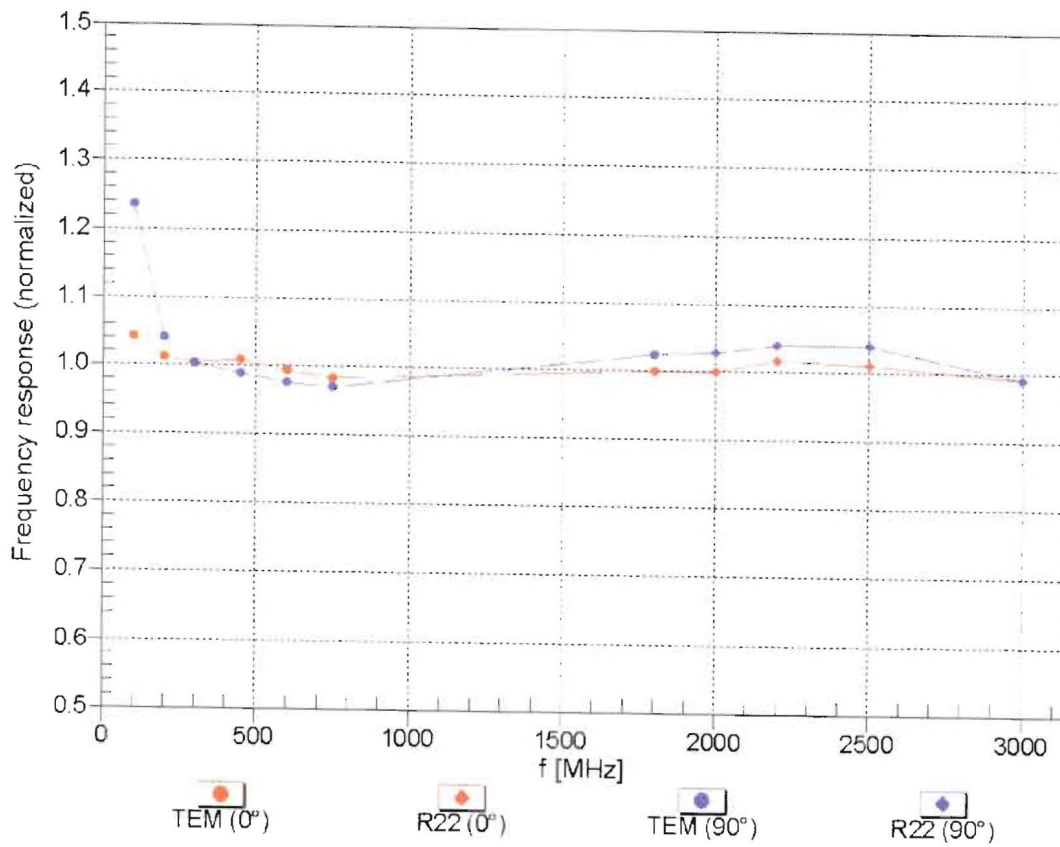
UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	135.3	$\pm 3.5 \%$
		Y	0.0	0.0	1.0		132.1	
		Z	0.0	0.0	1.0		136.4	

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

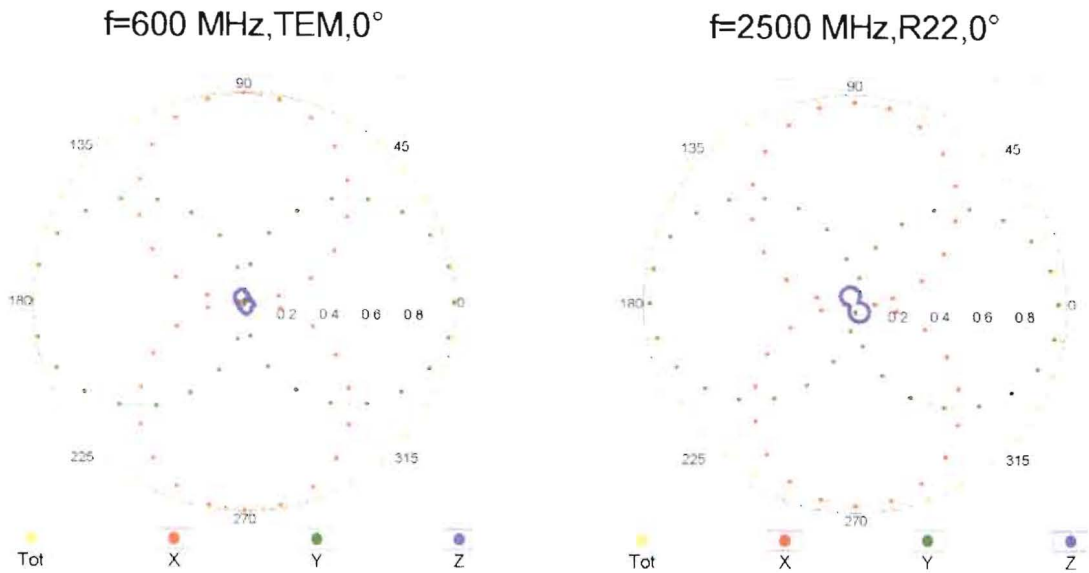
## Frequency Response of H-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



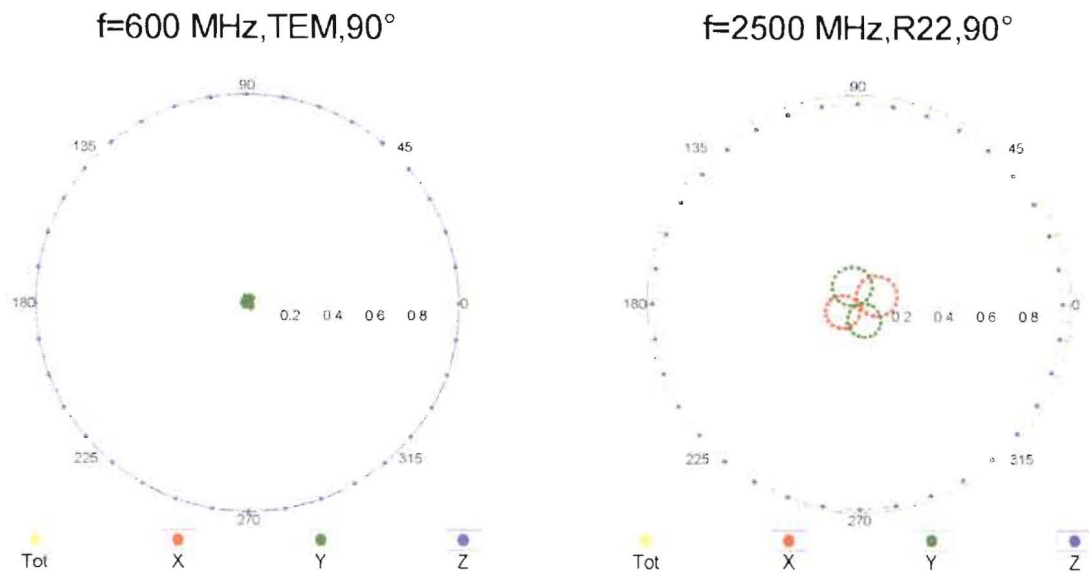
Uncertainty of Frequency Response of H-field:  $\pm 6.3\%$  (k=2)



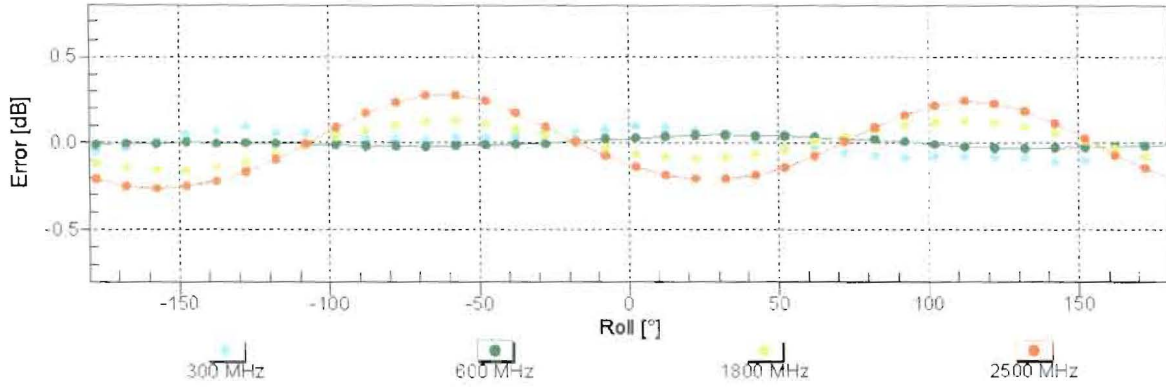
### Receiving Pattern ( $\phi$ ), $\vartheta = 0^\circ$



### Receiving Pattern ( $\phi$ ), $\vartheta = 90^\circ$

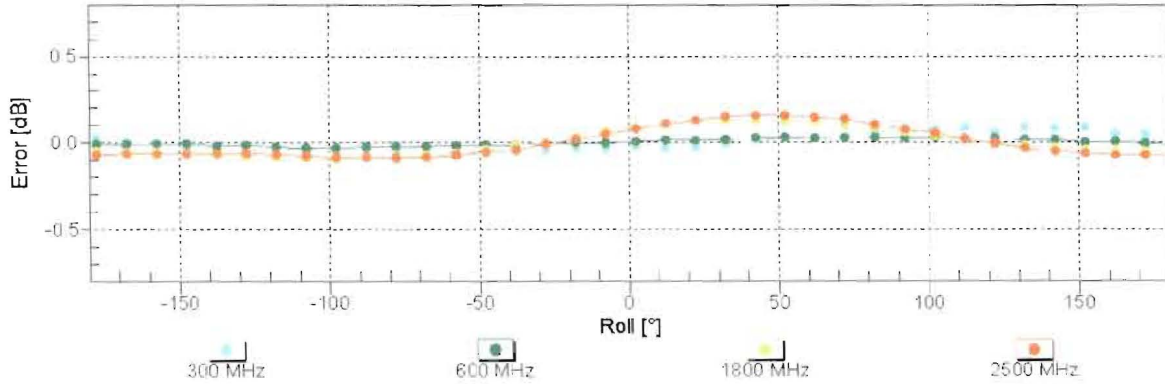


### Receiving Pattern ( $\phi$ ), $\vartheta = 0^\circ$



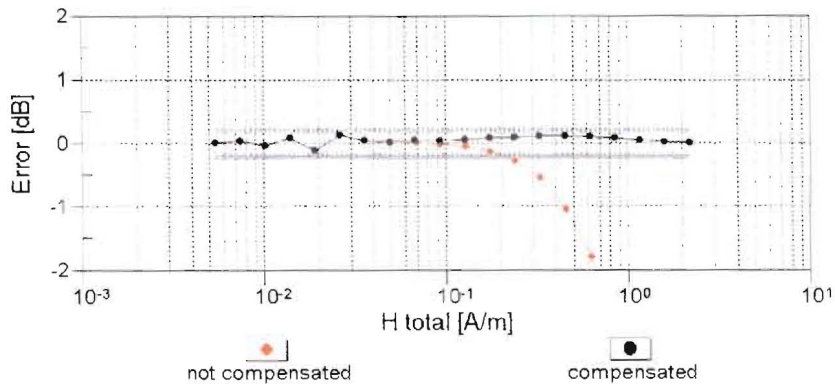
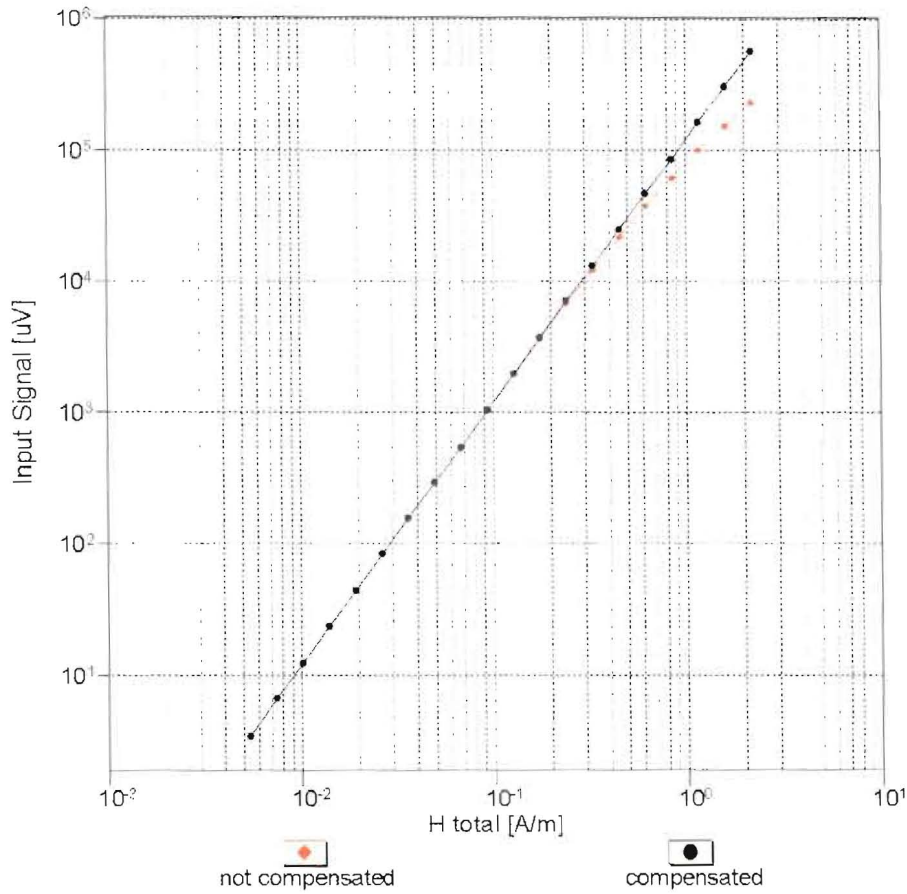
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

### Receiving Pattern ( $\phi$ ), $\vartheta = 90^\circ$



Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

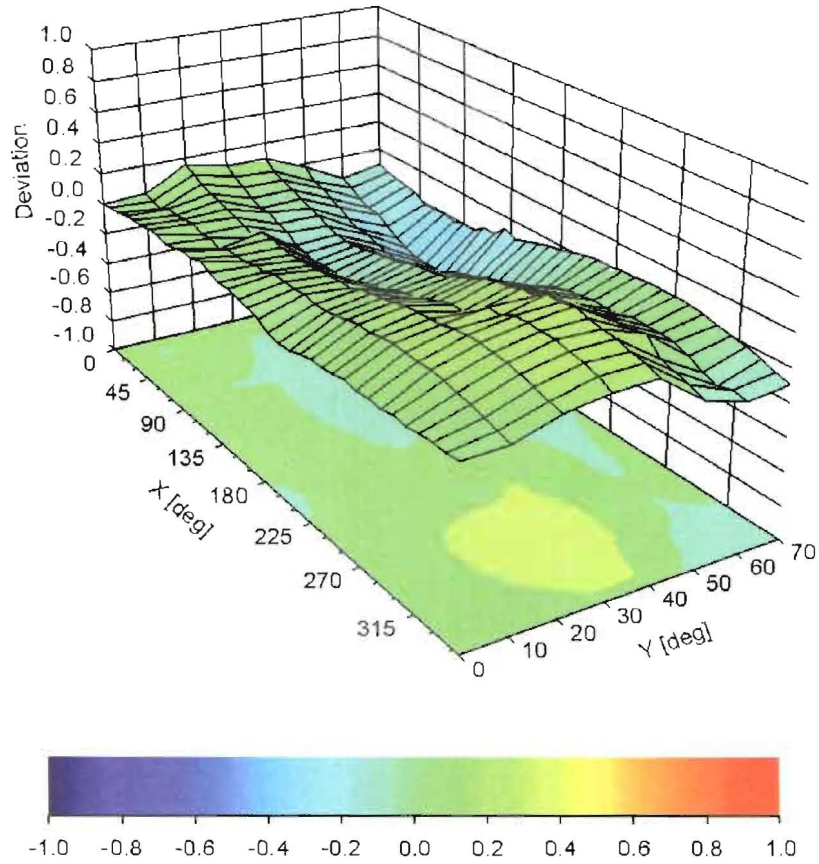
## Dynamic Range f(H-field) (TEM cell, f = 900 MHz)



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Deviation from Isotropy in Air

Error ( $\phi, \theta$ ),  $f = 900$  MHz



Uncertainty of Spherical Isotropy Assessment:  $\pm 2.6\%$  ( $k=2$ )

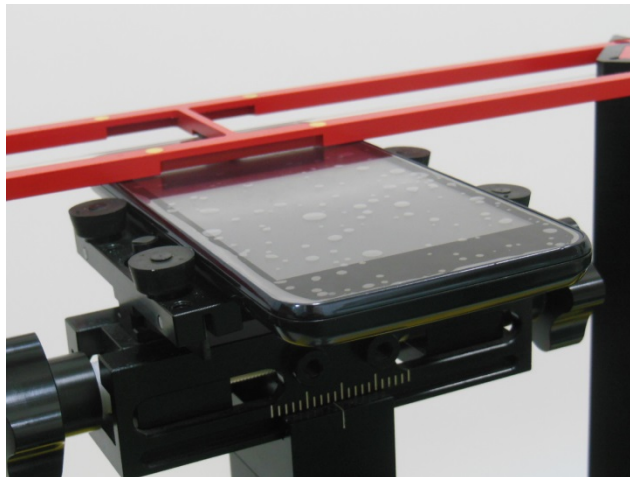
**DASY/EASY - Parameters of Probe: H3DV6 - SN:6342****Other Probe Parameters**

Sensor Arrangement	Rectangular
Connector Angle (°)	162.3
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	20 mm
Tip Diameter	6 mm
Probe Tip to Sensor X Calibration Point	3 mm
Probe Tip to Sensor Y Calibration Point	3 mm
Probe Tip to Sensor Z Calibration Point	3 mm

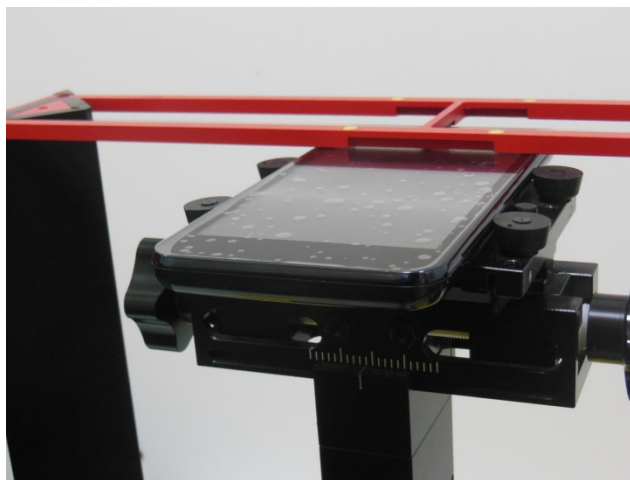
## Appendix D. Test Setup Photos



Front View



Left Side View



Right Side View